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# Search for Diffractive W's in CDF

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# SEARCH FOR DIFFRACTIVE W'S IN CDF

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ABSTRACT

We present the preliminary results of a search for diffractive $W^{\pm}$ production in $p\bar{p}$ collisions at $\sqrt{s}$=1800 GeV. The events used in this search were obtained with the CDF detector by triggering on a high Pt lepton and missing $E_T$. Diffractive $W's$ are tagged by the requirement of a rapidity gap on one side of the $\eta$-region. In events with rapidity gaps, the number of diffractive events is determined by using the correlations expected between the $\eta$ of the lepton, or the sign of its charge, with the side ($p$ or $\bar{p}$) of the rapidity gap.
We find that the ratio of diffractive to non-diffractive events is $R = 0.56 \pm 1.0\%$ (statistical only). This ratio has been calculated to be 17.2% assuming a pomeron with a hard structure function made up of $q\bar{q}$ pairs of the four light quarks.

## 1. Introduction

The exchange of a pomeron between two hadrons represents the particular combination of all parton exchanges that preserves the quantum numbers of the initial hadron states. In QCD, such a parton combination would be a colorless construct which, like a photon, does not fragment as it separates in rapidity space from the parent hadron, leading to events with a rapidity gap, i.e. a rapidity region void of particles.

The nature of the parton structure of the pomeron has attracted considerable attention since the UA8 experiment reported evidence for high $p_T$ dijet production in events attributed to single diffraction dissociation.[1] Analyzed in terms of primary parton interactions, the UA8 event topology supports a hard structure function for the pomeron. However, it can not distinguish between a hard-quark and a hard-gluon structure function.

The hard-quark content of the pomeron can be probed with diffractive $W^{\pm}$ production, which to leading order can occur only through $q\bar{q} \to W$. A hard-gluon dominated pomeron can also lead to diffractive $W's$ through the subprocess $gq \to Wq$, but at a rate lower by order $\alpha_s$ and always in association with a jet. Finally, the rate for a soft-gluonic pomeron is expected to be still lower. For the subprocesses illustrated in Fig. 1, the ratio of the diffractive to the total $W^{\pm}(\to l^{\pm}\nu)$ production cross section has been calculated[2] to be 17.2% for a hard-quark, 0.83% for a hard-gluon and 0.36% for a

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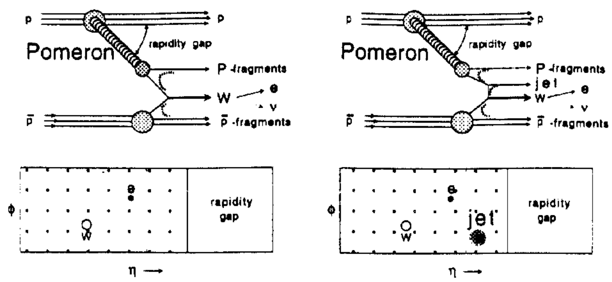



(a) qq--W (b) gq--Wq

Fig. 1

Diffractive W production

soft-gluon dominated pomeron. In this paper we report a measurement of this ratio and we use our result to evaluate the $q\overline{q}$ content of the pomeron structure function.

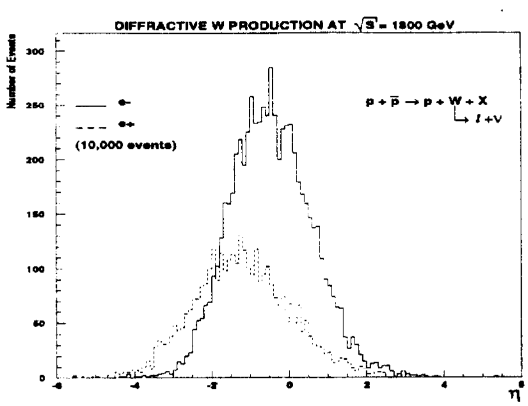
## 2. Analysis

The events used in this search contain a lepton($e^{\pm}$ or $\mu^{\pm}$) from $W \to l\nu$ decay. Diffractive $W's$ are tagged by the requirement of a rapidity gap on one side of the $\eta$-region, as shown in Fig. 1. Since rapidity gaps can also appear in non-diffractive events by fluctuations of the underlying event multiplicity, the sample of events with a rapidity gap is expected to contain a mixture of diffractive and non-diffractive events.

We use two methods to determine the fraction of diffractive events in a sample of events with rapidity gaps. The first method takes advantage of the diffractive event topology, which favors configurations in which the lepton is in the hemisphere opposite to that of the rapidity gap. The second method uses the correlation between the sign of the lepton charge and the side ($p$ or $\overline{p}$) of the rapidity gap. Proton-pomeron collisions, with the pomeron emitted from the antiproton, are expected to produce approximately twice as many $W^+$ as $W^-$ events, while the opposite is true for antiproton-pomeron collisions. This is due to the two $u(\overline{u})$ and one $d(\overline{d})$ quarks in the $p(\overline{p})$, as contrasted to the symmetric $q\overline{q}$ configuration, assuming equal contribution from $u$-type and $d$-type quarks, in the pomeron. Therefore, one expects that in diffractive $W$ production positive leptons from $W^+ \to l^+\nu$ will be associated mostly with rapidity gaps in the $\overline{p}$ direction, and negative leptons with rapidity gaps in the $p$ direction. For non-diffractive W's, no such correlation is expected.

The angle and charge asymmetries for leptons from diffractive $W(\to l\nu)$ production are evaluated using the POMPYT 1.0[3] and JETSET 7.3[4] simulation programs with a hard-$q\overline{q}$ structure function for the pomeron. The expected asymmetry is then used as an analyzer to determine the fraction of diffractive events from the corresponding asymmetry observed in the data sample. Figure 2 shows the $\eta$-distribution of electrons and positrons from diffractive W's generated by a Monte Carlo simulation using a hard-$q\overline{q}$ structure function for the pomeron. Because the events in Fig. 2 were generated with the pomeron emitted by the $p$, there are more electrons than positrons produced and they tend to be at negative $\eta$, opposite the rapidity gap in the $p$ direction (positive $\eta$).

The CDF detector is described in detail in reference 5. The detector components relevant to the selection of events with leptons from $W$ decay are described in reference 6. In this search we use the electromagnetic (EM) and hadron (HA) calorimeters to count particles. The CDF calorimeters have projective tower geometry and cover the region $-4.2 < \eta < 4.2$. A "particle" is defined as a tower (EM+HA) with transverse energy above 200 MeV. The size of a tower in $\Delta\eta$ x $\Delta\phi$ is 0.1 x 15° in the central region ($|\eta| < 1.1$) and 0.1 x 5° in the plug ($1.1 < |\eta| < 2.4$) and forward ($2.2 < |\eta| < 4.2$) regions. In this analysis we will be concerned mostly with counting the particle multiplicities in the forward calorimeters, which have 1440 towers on each side (positive or negative) of the $\eta$-region.



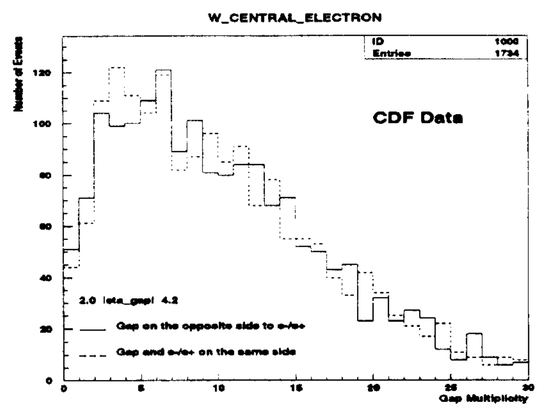




Figure 2: (*left*) Monte Carlo $\eta$ distribution of $e^+/e^-$ from diffractive W

Figure 3: (*right*) Gap multiplicity opposite, and same side as, $e^-/e^+$ in W data sample

This search was done on a data sample of W events obtained with a trigger that used only information on the electron or muon from the W, and on missing $E_T$. In particular, no information was required in the trigger that would bias the search for rapidity gaps in the forward regions, $2 < |\eta| < 4.2$. Three sets of data were used, characterized by the position of the electron or muon in pseudo-rapidity space: central and plug electrons, and central muons. After applying the standard W-selection requirements,[6] including, in addition, a cut retaining events with one vertex only, the number of events in these three categories was 1759, 988 and 1275, respectively.

The one vertex requirement was applied to the data in order to eliminate events with two interactions in the same beam-beam crossing. In diffractive W events, a second *minimum bias* interaction could eliminate the expected rapidity gap. The possibility also exists for the rapidity gap to be *erased* by particles from a second interaction that does not form a reconstructed vertex, or simply by calorimeter noise. The combined *gap survival probability* from both vertex-less additional interactions and from noise was measured by studying a sample of totally trigger-unbiased events, recorded by triggering the detector on beam-beam crossings. These events were collected during the same runs as the events of the W samples used in this analysis. From our analysis of this trigger-unbiased sample, we measure a gap survival probability of 86% in the region $2 < \eta < 4.2$ and 88% in $-4.2 < \eta < -2$ for the 200 MeV tower $E_T$ threshold used for counting particles.

Figure 3 shows the multiplicity distribution of towers for the central electron sample in the regions $2 < \eta < 4.2$ and $-4.2 < \eta < -2$, correlated (solid line) and anticorrelated (dashed line) with the electron angle. Diffractive W events would produce a net asymmetry ($A$) between the number of correlated ($N_{cor}$) and anticorrelated ($N_{\overline{cor}}$) events in the zero tower multiplicity bin: $A = (N_{cor} - N_{\overline{cor}})/(N_{cor} + N_{\overline{cor}})$. From Fig. 3, the angle-gap asymmetry for central $e^{\pm}$'s is $0.074 \pm 0.103$, while the central $\mu^{\pm}$'s and plug $e^{\pm}$'s asymmetries are $-0.070 \pm 0.101$ and $-0.028 \pm 0.118$ respectively. The charge-gap asymmetries are $-0.137 \pm 0.103$, $0.152 \pm 0.101$ and $-0.056 \pm 0.118$ for central $e^{\pm}$'s, central $\mu$'s and plug $e^{\pm}$'s respectively.

The efficiency for accepting diffractive events for a given rapidity gap width was determined by a Monte Carlo simulation, using the programs mentioned above. The expected lepton angle-gap and charge-gap correlation asymmetries for diffractive events were also determined by the simulation (see Fig. 2). These numbers were then used to extract the number of diffractive events from the lepton angle (or charge) vs side of rapidity gap asymmetry analysis.

## 3. Conclusions

The lepton angle-gap and charge-gap correlation analysis were combined for the entire sample. The preliminary result for the ratio of diffractive to non-diffractive W events is $R = 0.56 \pm 1.0\%$ (statistical only). This corresponds to an upper limit of $R < 2.2\%$ at the 95% confidence level, to be compared with $R = 17.2\%$ expected from a pomeron modelled completely by a hard-quark structure function.

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